



CLINICAL METHODS IN BLOOD PRESSURE.

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IN accordance with the request which has been addressed to me, the following remarks will be solely confined to aims, methods, and limitations in the clinical investigation of blood pressure. The results of the methods employed, the indications which they furnish, and the management of the conditions which they disclose will be fully dealt with by those who are to follow me in this discussion.

It may be taken for granted that our aims are now well understood and that they are also generally accepted. Putting them as shortly as possible, our objects are: (1) To ascertain the height of the blood pressure; (2) to analyse the factors concerned in its maintenance; and (3) to assess the relative importance of each of these agencies. It must be obvious that in any attempt to achieve those ends we must have a clear conception of the different influences which affect the pressure within the vessels. It will therefore be necessary to spend a few minutes in the consideration of the factors upon which the pressure depends.

The blood pressure is due primarily to the energy of the heart shown by amount of outflow and velocity of expulsion. All the cardiac functions, rhythmicity, excitability, contractility, conductivity, and tonicity must take part in this. Undoubtedly the intrinsic energy of the heart is subject to extrinsic conditions, such as the amount of blood which reaches it by way of the great veins, and the resistance which it has to overcome. Increased rate, with free access of blood, as a rule raises the pressure and vice versa, yet in such conditions as heart-block the pressure may be up to 250 mm. Hg. Any lessening of the afferent blood diminishes blood pressure; every increase in resistance raises it up to a certain level, but if the resistance is too high the outflow is reduced and the pressure falls. The cardiac energy may further be increased or diminished by the influence of the augmenting and inhibiting nerves. By means of the nervous mechanism, moreover, the heart is automatically relieved from the effects of overwork. As regards the action of the heart, then, we may conclude that any

increase in the outflow from the ventricles raises the blood pressure when the other factors are constant, and, conversely, a diminution produces a fall. This may be due to increased velocity, caused by the action of the augmentor nerves without any acceleration of rate.

The peripheral resistance has great importance in maintaining the blood pressure, and this on analysis is found to depend on several different causes. The tone of the blood vessels, maintained by the influence of the vaso-motor nerves upon the unstriated muscular tissue of the vascular walls, is the most powerful factor in this connexion. Undoubtedly the general tone is due to a balance between the influence of the vaso-constrictor and vaso-dilator nerves, but as the latter are not continuously in action they may be disregarded. Time forbids my entering upon the subject, but you will allow me simply to recall the well-known fact that if the tone of the blood vessels is seriously lowered, there is more or less complete venous stasis, and greater or less failure of the circulation from lack of blood reaching the heart. The tone of the blood vessels presents general and local variations. The general blood pressure responds to the general tone of the blood vessels throughout the entire circulation, but it must not be overlooked that the local pressure undergoes great vicissitudes in accordance with special requirements. The most remarkable facts bearing out this statement are derived from the abdominal vessels under the influence of the splanchnic nerves. Some new facts have recently been brought forward on this subject by Rudolf, and the matter will require further investigation. An increase of function in any particular area produces an increased blood supply through the action of the vaso-dilator nerves, leading to dilatation of the smaller arteries. Conversely, cessation of function in any part is at once followed by the resumption of the normal tone exerted by the vaso-constrictor nerves. Further, it has been proved that the general as well as the local blood pressure is subject to reflex influences arising even in distant parts. With reference to this part of the subject, we may say that, other factors being constant, increased resistance is associated with higher, and lessened resistance with lower, pressure.

Vascular elasticity is of great importance. By its means the energy of the heart is, as it were, transferred to the vessel walls in the form of potential, continuously becoming kinetic energy, and in this way the onward movement of the blood is subject to a much more continuous influence than would be possible were it solely dependent upon the intermittent energy of the heart. When the structure of the blood vessels is intact, they possess extremely wide limits of elasticity, meaning that their walls can return to normal after great distension. When this wide limit of elasticity is narrowed by morbid changes, there is an increased resistance to the blood flow, and at the same time a tendency to distension of the vessels from which recovery is no longer possible.

The amount of blood in circulation is certainly of some importance in regard to blood pressure, but it has less influence than the factors which have just been considered. The only available method of ascertaining the amount of blood in the vessels is the carbonic oxide process of Haldane, which many of us hesitate to use in our clinical investigations. The comparatively slight effect of changes in the contents of the vessels is obviously due to the fact that variations in the amount of blood speedily bring about compensatory alterations in the tone of the blood vessels, as well as the energy of the heart, so that they adapt themselves to the quantity they contain, and restore the pressure to the normal for the conditions which are present. Our knowledge of this subject is chiefly the result of experimental physiology, as regards additions to the amount of blood in circulation. Physiological researches on the effects of reduction of the amount are borne out by observations upon cases of severe hæmorrhage in practice. The data obtained from both sources of information lead us to the conclusion that changes in the volume of the blood only produce transient effects on blood pressure.

The viscosity of the blood is another factor which undoubtedly has some importance; the amount of weight to be attached to this influence is at present largely a matter of speculation. As there is always a layer of blood, more or less stationary, in contact with the walls of the blood vessels, the viscosity is probably not very important. A simple and ingenious process for the estimation of the viscosity of the blood has recently been described by Denning and Watson.

We have now to approach the questions involved in the attempt to estimate blood pressure in clinical medicine. We sometimes, even in this new century, hear it said by distinguished teachers that the educated finger is the best means of judging the arterial pressure; to the initiated such a statement is grotesque in the extreme. Undoubtedly the sense of touch, aided by a long experience, is of considerable value, and it is the duty of each of us to train the fingers to the best of our ability; yet the man who will gravely say that he is able to gauge the blood pressure by means of his fingers is quite as foolish as another man would be who gravely stated that he was able to take accurate temperature readings by applying his hand to the surface of the patient. During the last thirty years my efforts in training myself to assess blood pressure by the sense of touch have taught how extremely fallacious such a method must always be. Its results only give at the best distant approximations to truth when compared with the readings of a reliable modern instrument. The finger never can and never will give us such a warning, for example, as the sphygmomanometer does in cases of pneumonia. As is known to all of us the normal course in this disease is to a continuous but gradual fall of pressure. Any sudden rise before the crisis means some complication, and acute delirium is

often the immediate sequel to a sudden rise of pressure; while any sudden fall of pressure suggests complications of another kind, and warns us of the immediate risk of cardiac failure. Those teachers who still oppose the use of our modern instruments of research in the investigation of blood pressure are on the same level as those who condemn the employment of such instruments as the ophthalmoscope.

The instrumental estimation of blood pressure may be carried out by several methods; the oldest clinical procedure was that of Vierordt, who just over half a century ago made the earliest attempts to ascertain the blood pressure with his own sphygmograph, weighted so as to compress the artery. This was really the first attempt in the clinical estimation of arterial pressure. Undoubtedly the sphygmograph furnishes certain indications as regards blood pressure, but nothing more. As we shall see, sphygmomanometers locally applied to the radial artery are liable to fallacies, and this is even more true of the sphygmograph. It plays its part in revealing to us the rhythm of movements, it gives indistinct suggestions of high and low pressure; but it helps us scarcely at all in judging of the energy by which the arterial movements are produced, and it does not give more than a distant approximation to the results in the vessels.

This is even more true of the cardiograph, in which the sources of fallacy are even greater than in the sphygmograph. The relations of the heart to the lungs and to the chest walls, as well as the condition of the parietes, constitute such variable conditions as to render any attempts to estimate the energy of the circulation with the cardiograph absolutely nugatory.

Since the earliest serious efforts made by von Basch, a quarter of a century ago, many useful instruments have been devised for the estimation of blood pressure. In considering these different instruments we shall find that they fall into various groups. There are, for instance, the sphygmomanometers of von Basch, Potain, and Oliver, as well as the smaller instrument of Hill and Barnard, which estimate the blood pressure by application directly to the radial artery. There are others which aim at obtaining readings by the circular compression of the limb; to this series belong the larger instrument of Hill and Barnard, and the sphygmomanometers of Riva-Rocci, Martin, Cook, Stanton, Janeway, and Erlanger. There are further methods of estimating the blood pressure by apparatus embracing the extremities; to this category belong the apparatus of Marey, Hürthle, and Mosso. We have, further, instruments designed to estimate blood pressure by the tint of the skin. The tonometer of Gärtner is an example of the application of this principle. But when we more fully analyse these different instruments we find that there are many other points of view from which we may regard them, and therefore the analysis of the apparatus requires more careful consideration.

When these different instruments are analysed from

the point of view of their principles we find them grouped in quite another fashion. The instruments which gauge the pressure by obliteration of pulsation may be grouped according to their mode of application. In this way we may say that the apparatus of von Basch and of Potain act by local obliteration of the arterial pulse, as judged by applying the finger or some recording apparatus immediately beyond the point of application of the instrument. Those of Riva-Rocci, Martin, Cook, Stanton, and Janeway obliterate the pulse in one of the larger arteries, and the effects are estimated by examination of an artery further from the centre. There is also the instrument of Gärtner, which obliterates the pulsation in one of the fingers, its effects being judged by the return of colour to the skin.

All these different methods give the systolic or end pressure, but the instruments are of very different value. The instruments of von Basch and Potain are not so defective in principle as in method, and their fallacies chiefly consist in faults of application. In view of the variabilities in the position of the radial artery, both as regards its relations to the underlying bone and the differences in the tissue by which the artery is surrounded, it must be obvious that the correct application of either instrument is far from easy, and the readings which have been obtained show how liable these methods are to error. The plan of circular compression and estimation of the blood pressure, judged by the return of pulsation beyond the point of compression on reduction of the compressing force, gives results which are extremely accurate, provided, as von Recklinghausen showed, the armlet is sufficiently broad to bear a certain proportion to the size of the limb. From his observations it is clear that if a narrow band is employed, especially with high pressures, the readings are too high. It may possibly be urged that, as in these instruments the return of pulsation after complete cessation is judged by the application of the finger, the subjective element comes into observation. This subject has, however, been thoroughly investigated by the use of a delicate sphygmograph or another sphygmomanometer on the distal side of the compressing band, by which it has been proved that the return of pulsation can be gauged by the finger with extreme accuracy. One important point as regards all these instruments is that they not merely record the systolic, but, as will be mentioned afterwards, the diastolic pressure.

In the instrument of Gärtner, the same principle of circular compression is involved, but on the removal of the pressure the return of pulsation is judged by the return of colour to the skin. This instrument is faulty in respect of the difficulty of accurate application of the compressing ring, which involves considerable errors. Undoubtedly another defect comes with the mode of estimation, seeing that the return of the arterial tide is judged by the tint of the skin, in which there is a large possibility of error. We must allow that the sight is probably

our most accurate sense; fully realizing this, nevertheless, in my own experience the skin varies so greatly in its texture as to render it uncertain when the first tide of returning blood takes place. In addition to this the flushing often occurs very gradually, so that it is difficult to determine exactly when it really shows itself. It must further be remarked that the greatest source of error is that very small arteries are taken for investigation—vessels which are extremely liable to variations of vasomotor activity. Gellinek's interesting researches have proved how unreliable the tonometer is from such causes.

The pulse pressure is gauged by the maximum excursions of the recording apparatus in the instruments of Marey, Hürthle, Mosso, Hill and Barnard, and Oliver. In these the theory is that when the pressure surrounding the vessel and that within the vessel are equal, the oscillations attain their maximum. In every one of these instruments the readings are those of diastolic pressure, and the mode of estimation consists in recording the lowest level of maximum pulsation.

The instruments of Marey, Hürthle, and Mosso are applied to the digits, that of Oliver to the radial artery, while one of Hill and Barnard's instruments is applied directly to the radial artery, and the other adopts the method of circular compression. The instruments of Marey, Hürthle, and Mosso can only be regarded as of use in the laboratory; that of Oliver possesses inherent defects of application which render it unreliable. Hill and Barnard's smaller sphygmometer cannot really be regarded seriously, and their larger instrument alone remains in this class worthy of consideration from the clinical point of view. It unfortunately only records the diastolic pressure, which in itself is of little value unless compared with systolic pressure. In some of the cases, also, in which readings are of the greatest utility (such as aortic incompetence), the lower limit of maximum oscillation is difficult to determine. Moreover, unless the narrow armlet, which is provided with the instrument, be replaced by a broad one, the readings are much too high.

It has already been mentioned that the instruments of Riva-Rocci, Martin, Cook, Stanton, and Janeway, afford an estimate of diastolic as well as systolic pressure. It has to be allowed that in these instruments it is only an approximation to a true estimate of the diastolic pressure which is yielded, but with a little practice the lowest point at which the maximum oscillation of the mercury occurs can be obtained without difficulty. The only instrument which measures both systolic and diastolic pressure accurately, and gives records by graphic methods, is the sphygmomanometer of Erlanger. It is based upon the same principles as those of Riva-Rocci, Stanton, and Janeway—that is, by circular compression of the limb the pulsation is obliterated beyond the band, and the point at which the return of pulsation occurs is noted on the column of mercury. In addition to this there is a most admirable arrangement for recording the oscillations of

pressure, and by a most ingenious stopcock the pressure can be graduated to a nicety.

My own observations in blood pressure have been confined to work done with the instruments of Oliver, Hill and Barnard, Gärtner, Riva-Rocci, and Erlanger; but, during the two years which have just elapsed, the two last mentioned have alone been employed. It may be added, however, that the instrument of Janeway will be one of my clinical companions in the future, as, on account of its portability, it is most convenient to take about. There is every reason for complete satisfaction with the instruments of Riva-Rocci, Janeway, and Erlanger. They are easily applied, and, with a little practice, there are no difficulties in obtaining accurate readings.

Owing to an unfortunate misunderstanding * the instrument of Erlanger only reached me a few weeks ago, and my opportunities of employing it have therefore been somewhat limited. It has, however, been sufficiently used in my own clinic to arouse the admiration of every one who has seen it.

The effects of posture will be considered immediately. All that need be said here is that the patient must be as nearly as possible horizontal, and in an easy position. He must rest upon some firm article of furniture in order to prevent any liability to movement, and the arm should be in such a position as to be absolutely at rest. It need hardly be added that any tendency to spasm or tremor will render readings inaccurate, while adiposity and oedema militate against the possibility of accurate observation.

It is necessary to have absolutely clear conceptions of the normal limits of blood pressure before attempting estimates in any individuals. From numerous observations with modern instruments by many reliable observers, it may be stated that in the young adult the normal systolic pressure does not exceed the limits of from 90 to 140, while the diastolic varies between 60 and 110. These limits are, however, frequently exceeded, especially in nervous individuals.

Until middle life there appears to be no very great departure from these limits, but after middle life there is a steady rise of pressure. To this subject Clifford Allbutt has given great attention, and we look forward to his remarks to-day with great interest. In persons at this time of life, however, it is extremely difficult to be certain whether we are dealing with healthy conditions—that is to say, with conditions normal to the age of the individual or with conditions which are abnormal.

There are undoubtedly variations in blood pressure which must be accounted normal, and in studying the

* It is my duty to warn any intending purchasers of Erlanger's instrument to beware of the Southern Speciality Company of Baltimore, who used to be, but are no longer, the authorized makers. The present makers are Messrs. Schneider Brothers, Green Street, New York, who are to be implicitly trusted for excellence of workmanship.

blood pressure in any individual these have to be borne in mind. There are daily fluctuations, probably produced by the sum total of the different influences affecting blood pressure. As a general rule, the pressure reaches its highest level in the forenoon, but it usually shows an afternoon rise as well. The knowledge that such changes exist will necessarily lead us to take our readings at the same hour as far as possible.

The influence of food is somewhat variable; sometimes a rise of pressure is found after a meal, but almost as frequently there is a fall. The fall is easily accounted for by the diversion of blood into the abdominal region. This, however, is often compensated for by reflex stimulation of the vasomotor system, while the entrance of the food elements into the circulation undoubtedly has a tendency to raise blood pressure. All readings of the blood pressure must be taken with this consideration in view. William Russell has recently made some interesting observations on this subject.

The posture has considerable influence. There is not much difference between lying and sitting, but there is a considerable difference between sitting and standing. It is interesting to notice that on changing the position from lying to sitting, and again from sitting to standing, the diastolic pressure is that which is chiefly elevated, and therefore the pulse-pressure variation is lessened in the upright position.

Occupation has a most important influence upon pulse pressure, and it is therefore necessary to note what the individual has been about previous to taking pressure readings. This is true both of physical and mental exertion, but probably a combination of the two will bring about the highest increase. My own blood pressure, which under ordinary circumstances is about 150 or 155, has frequently been measured immediately after the exertion of conducting a clinic in the Royal Infirmary, and it has sometimes reached the level of 185 or 190.

It is undoubtedly true that all persons who pass through lives of considerable exertion have a higher pressure than those whose expenditure of energy is on a lower level. The occupation of the individual has therefore to be taken into account in all blood-pressure readings.

We are still in want of careful estimations of the blood pressure in relation to the use of certain articles much employed amongst us, such as alcohol and tea. It is probable that the influence of alcohol, beyond a slight initial rise due to acceleration of the heart, is to produce diminution of pressure. Tobacco behaves in a different fashion, and by its influence upon the vaso-constrictor apparatus it produces a very great increase of blood pressure. This accords with many of the French observations, in which hypertonus and arterial sclerosis have been found as the result of the excessive use of tobacco.

External temperature undoubtedly has some influence, but we lack sufficient observations upon the subject. The

general result of such observations as those of Müller is to show that when the patient is subjected to any departure from the normal external temperature the pulse pressure is apt to rise. This is especially seen in the influence of baths. The possible effect of changes in the external temperature must always be borne in mind in taking any readings.

In every case under continuous observation blood pressure readings ought to be noted on a chart, as is urged by Janeway. Without such graphic means of recording the pressure, it is difficult to grasp the significance of the figures. Nothing could show this better than charts taken from a case of acute disease, such as pneumonia. The physician in charge will always feel anxious when he observes that the pulse curve has a higher range than the pressure curve. Some of the charts which are now submitted show this most markedly. The same may be said of the utility of charts in cases of grave disturbance of the circulation or of the kidneys. Any wide discrepancy between the action of the heart and the pressure of the pulse will give us anxiety.

It must be obvious that the limitations which surround our attempts to estimate the absolute value of blood pressure consist to a large extent in the difficulties which beset us in the analysing of the different factors maintaining blood pressure. The relative amounts of energy and of resistance are still a sealed book. An absolutely low general blood pressure may be one which is relatively too high for the energy of the heart; while, on the other hand, a pressure which appears to be abnormally high may be one which is quite low in relation to the energy of the heart. The fact that arterial spasm, general or local, has an important influence in modifying the blood pressure, has always to be borne in mind; as a disturbing factor it may produce rapid changes in its level.

It is my duty, in conclusion, to pay a warm tribute to the numerous observers in Canada and the United States whose important investigations and valuable results have laid us under a great debt of gratitude. In my hand there is a fairly exhaustive list of the really important works on blood pressure, and the American Continent may well be proud of the prominent place occupied by her investigators. It is only right to express, further, my deep sense of the generosity which has led Western observers, from whom we have learned so much, to invite such a large number of us from the Old Country to take part in this discussion.

